CLAIMS

1. A method for canceling multiple user interference in a communications system wherein a plurality of users communicate over a shared channel, the method comprising:

receiving an input that provides a plurality of discrete values produced at sub-symbol intervals that are less than a full symbol period, wherein a current discrete value corresponds to a current sub-symbol interval for a current symbol and a previous discrete value corresponds to a previous sub-symbol interval for the current symbol; and

estimating symbols for a given user from the plurality of users at sub-symbol intervals, wherein a current estimation for the given user estimates a portion of the current discrete value that corresponds to the current symbol for the given user and cancels interference produced by the plurality of users as determined from the previous discrete value during the previous sub-symbol interval.

2. The method of claim 1, wherein the communications system is a code division multiplex access communications system.

3. The method of claim 1, wherein the sub-symbol intervals are chip intervals.

4. The method of claim 1, wherein estimating symbols for the given user is performed by a plurality of processing stages.

5. The method of claim 1, wherein a plurality of processing elements respectively perform estimations for each of the plurality of users at sub-symbol intervals to accommodate canceling interference produced by the plurality of users.

6. The method of claim 4, wherein the plurality of processing stages includes a first stage

and a second stage, the first stage providing an accumulated soft symbol output for the given user to the second stage, the second stage estimating symbols for the given user using the accumulated soft symbol output.

7. The method of claim 6, wherein the input as received by the second stage is delayed by a symbol period relative to that received by the first stage.

8. The method of claim 1, wherein symbol estimation is based upon one of a minimum mean squared error estimate.

9. The method of claim 8, wherein the minimum mean squared error estimate is a linear mean squared error estimate.

10. The method of claim 1, wherein symbol estimation is based upon a mixed Gaussian distribution.

11. The method of claim 4, wherein individual stages from the plurality of processing stages are of different types.

12. The method of claim 4, wherein each processing stage in the plurality of processing stages performs a multi user detection algorithm selected from the group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

13. The method of claim 4, wherein each processing stage in the plurality of processing stages includes a recursive multistage demodulator.

14. The method of claim 13, wherein the recursive multistage demodulator includes gain factor and non-linear function modules that are reconfigurable to allow corresponding processing

stages to perform a multi user detection algorithm selected from the group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

15. An apparatus for canceling multiple user interference in a communications system wherein a plurality of users communicate over a shared channel, the method comprising:

an input that receives a plurality of discrete values produced at sub-symbol intervals that are less than a full symbol period, wherein a current discrete value corresponds to a current sub-symbol interval for a current symbol and a previous discrete value corresponds to a previous sub-symbol interval for the current symbol; and

a first processing stage, in communication with the input, that estimates symbols for a given user at sub-symbol intervals, wherein a current estimation for the given user estimates a portion of the current discrete value that corresponds to the current symbol for the given user and cancels interference produced by the plurality of users as determined from the previous discrete value during the previous sub-symbol interval.

16. The apparatus of claim 15, wherein the communications system is a code division multiplex access communications system.

17. The apparatus of claim 15, wherein the sub-symbol intervals are chip intervals.

18. The apparatus of claim 15, wherein the first processing stage is one of a plurality of processing stages used to estimate symbols for the given user.

19. The apparatus of claim 15, wherein the processing stage comprises a plurality of processing elements that respectively perform estimations for each of the plurality of users at

sub-symbol intervals to accommodate canceling interference produced by the plurality of users.

20. The apparatus of claim 18, wherein the plurality of processing stages includes a first stage and a second stage, the first stage providing an accumulated soft symbol output for the given user to the second stage, the second stage estimating symbols for the given user using the accumulated soft symbol output.

21. The apparatus of claim 15, wherein the first processing stage implements a minimum mean squared error estimate in estimating symbols.

22. The apparatus of claim 21, wherein the minimum mean squared error estimate is a linear mean squared error estimate.

23. The apparatus of claim 15, wherein the first processing stage implements a mixed Gaussian distribution in estimating symbols.

24. The apparatus of claim 18, wherein individual stages from the plurality of processing stages are of different types.

25. The apparatus of claim 18, wherein each processing stage in the plurality of processing stages performs a multi user detection algorithm selected from the group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

26. The apparatus of claim 18, wherein each processing stage in the plurality of processing stages includes a recursive multistage demodulator, the recursive multistage demodulator further including gain factor and non-linear function modules that are reconfigurable to provide corresponding processing stages that perform a multi user detection algorithm selected from the

group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

27. A computer program product for canceling multiple user interference in a communications system wherein a plurality of users communicate over a shared channel, the computer program product stored on a computer readable medium and adapted to perform operations comprising:

receiving an input that provides a plurality of discrete values produced at sub-symbol intervals that are less than a full symbol period, wherein a current discrete value corresponds to a current sub-symbol interval for a current symbol and a previous discrete value corresponds to a previous sub-symbol interval for the current symbol; and

estimating symbols for a given user from the plurality of users at sub-symbol intervals, wherein a current estimation for the given user estimates a portion of the current discrete value that corresponds to the current symbol for the given user and cancels interference produced by the plurality of users as determined from the previous discrete value during the previous sub-symbol interval.

28. The computer program product of claim 27, wherein the communications system is a code division multiplex access communications system.

29. The computer program product of claim 27, wherein the sub-symbol intervals are chip intervals.

30. The computer program product of claim 27, wherein the symbols are multiple bit symbols.

31. A method for canceling multiple user interference in a communications system wherein a plurality of users communicate over a shared channel, the method comprising:

receiving an input that provides a plurality of discrete values produced at sub-symbol intervals that are less than a full symbol period, wherein a current discrete value corresponds to a current sub-symbol interval for a current multiple bit symbol and a previous discrete value corresponds to a previous sub-symbol interval for the current multiple bit symbol; and

estimating symbols for a given user from the plurality of users at sub-symbol intervals, wherein a current estimation for the given user estimates a portion of the current discrete value that corresponds to the current multiple bit symbol for the given user and cancels interference produced by the plurality of users as determined from the previous discrete value during the previous sub-symbol interval.

32. The method of claim 31, wherein the communications system is a code division multiplex access communications system.

33. The method of claim 31, wherein the sub-symbol intervals are chip intervals.

34. The method of claim 31, wherein estimating symbols for the given user is performed by a plurality of processing stages.

35. The method of claim 31, wherein a plurality of processing elements respectively perform estimations for each of the plurality of users at sub-symbol intervals to accommodate canceling interference produced by the plurality of users.

36. The method of claim 34, wherein the plurality of processing stages includes a first stage and a second stage, the first stage providing an accumulated soft symbol output for the given

user to the second stage, the second stage estimating symbols for the given user using the accumulated soft symbol output.

37. The method of claim 36, wherein the input as received by the second stage is delayed by a symbol period relative to that received by the first stage.

38. The method of claim 31, wherein symbol estimation is based upon one of a minimum mean squared error estimate.

39. The method of claim 38, wherein the minimum mean squared error estimate is a linear mean squared error estimate.

40. The method of claim 31, wherein symbol estimation is based upon a mixed Gaussian distribution.

41. The method of claim 34, wherein individual stages from the plurality of processing stages are of different types.

42. The method of claim 34, wherein each processing stage in the plurality of processing stages performs a multi user detection algorithm selected from the group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

43. The method of claim 34, wherein each processing stage in the plurality of processing stages includes a recursive multistage demodulator.

44. The method of claim 43, wherein the recursive multistage demodulator includes gain factor and non-linear function modules that are reconfigurable to allow corresponding processing stages to perform a multi user detection algorithm selected from the group consisting of mixed

Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

45. An apparatus for canceling multiple user interference in a communications system wherein a plurality of users communicate over a shared channel, the method comprising:

an input that receives a plurality of discrete values produced at sub-symbol intervals that are less than a full symbol period, wherein a current discrete value corresponds to a current sub-symbol interval for a current multiple bit symbol and a previous discrete value corresponds to a previous sub-symbol interval for the current multiple bit symbol; and

a first processing stage, in communication with the input, that estimates symbols for a given user at sub-symbol intervals, wherein a current estimation for the given user estimates a portion of the current discrete value that corresponds to the current multiple bit symbol for the given user and cancels interference produced by the plurality of users as determined from the previous discrete value during the previous sub-symbol interval.

46. The apparatus of claim 45, wherein the communications system is a code division multiplex access communications system.

47. The apparatus of claim 45, wherein the sub-symbol intervals are chip intervals.

48. The apparatus of claim 45, wherein the first processing stage is one of a plurality of processing stages used to estimate symbols for the given user.

49. The apparatus of claim 45, wherein the processing stage comprises a plurality of processing elements that respectively perform estimations for each of the plurality of users at

sub-symbol intervals to accommodate canceling interference produced by the plurality of users.

50. The apparatus of claim 48, wherein the plurality of processing stages includes a first stage and a second stage, the first stage providing an accumulated soft symbol output for the given user to the second stage, the second stage estimating symbols for the given user using the accumulated soft symbol output.

51. The apparatus of claim 45, wherein the first processing stage implements a minimum mean squared error estimate in estimating symbols.

52. The apparatus of claim 51, wherein the minimum mean squared error estimate is a linear mean squared error estimate.

53. The apparatus of claim 45, wherein the first processing stage implements a mixed Gaussian distribution in estimating symbols.

54. The apparatus of claim 48, wherein individual stages from the plurality of processing stages are of different types.

55. The apparatus of claim 48, wherein each processing stage in the plurality of processing stages performs a multi user detection algorithm selected from the group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

56. The apparatus of claim 48, wherein each processing stage in the plurality of processing stages includes a recursive multistage demodulator, the recursive multistage demodulator further including gain factor and non-linear function modules that are reconfigurable to provide corresponding processing stages that perform a multi user detection algorithm selected from the

group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

57. A method for canceling multiple user interference in a communications system wherein a plurality of users communicate over a shared channel, the method comprising:

receiving a set of data that provides a plurality of discrete values produced at a sub-symbol interval that is less than a full symbol period; and

estimating bits for a symbol corresponding to a given user by interpolating the signature waveforms for at least some of the plurality of users to a common sampling lattice of the received set of data.

58. The method of claim 57, wherein the communications system is a code division multiplex access communications system.

59. The method of claim 57, wherein the communications system is an asynchronous code division multiplex access communications system.

60. The method of claim 57, wherein the sub-symbol interval is a chip interval.

61. The method of claim 57, further comprising:

using the interpolated signature waveforms to determine an interference contribution corresponding to the given user.

62. The method of claim 61, wherein the interpolated signature waveform is used to perform signal reconstruction for a first sub-symbol interval and is retained to estimate bits in a second sub-symbol interval that follows the first sub-symbol interval.

63. The method of claim 62, wherein a sub-symbol delay accommodates concurrently

retaining the interpolated signature waveform for bit estimation in the second sub-symbol interval and for signal reconstruction for the first sub-symbol interval.

64. The method of claim 57, wherein a plurality of decoupled multi-user detection processing elements respectively determine the interference contributions for each of the plurality of users at the sub-symbol interval.

65. The method of claim 64, further comprising:

determining a current interference estimate for a current sub-symbol interval by combining the determined interference contributions for each of the plurality of users;

removing the current interference estimate from the set of data to provide an innovation signal; and

using the innovation signal to estimate bits for the given user in the current sub-symbol interval and determine a next interference estimate for each of the plurality of users corresponding to the next sub-symbol interval.

66. The method of claim 57, wherein the symbol is a multiple bit symbol.

67. An apparatus for canceling multiple user interference in a communications system wherein a plurality of users communicate over a shared channel, the apparatus comprising:

an input that receives a set of data that provides a plurality of discrete values produced at a sub-symbol interval that is less than a full symbol period; and

a multi-user detection module that estimates bits for a symbol corresponding to a given user by interpolating the signature waveforms for at least some of the plurality of users to a common sampling lattice of the received set of data.

68. The apparatus of claim 67, wherein the communications system is a code division multiplex access communications system.

69. The apparatus of claim 67, wherein the communications system is an asynchronous code division multiplex access communications system.

70. The apparatus of claim 67, wherein the sub-symbol interval is a chip interval.

71. The apparatus of claim 67, wherein the multi-user detection module uses the interpolated signature waveforms to determine an interference contribution corresponding to the given user.

72. The apparatus of claim 71, wherein the interpolated signature waveform is used to perform signal reconstruction for a first sub-symbol interval and is retained to estimate bits in a second sub-symbol interval that follows the first sub-symbol interval.

73. The apparatus of claim 72, wherein a sub-symbol delay accommodates concurrently retaining the interpolated signature waveform for bit estimation in the second sub-symbol interval and for signal reconstruction for the first sub-symbol interval.

74. The apparatus of claim 67, wherein a plurality of decoupled multi-user detection modules respectively determine the interference contributions for each of the plurality of users at the sub-symbol interval.

75. The apparatus of claim 74, further comprising:

means for determining a current interference estimate for a current sub-symbol interval by combining the determined interference contributions for each of the plurality of users;

means for removing the current interference estimate from the set of data to provide an

innovation signal, wherein the multi-user detection modules are configured to use the innovation signal to estimate bits for the current sub-symbol interval and determine a next interference estimate for each of the plurality of users corresponding to the next sub-symbol interval.

76. The method of claim 67, wherein the symbol is a multiple bit symbol.

77. A system for canceling multiple user interference in a communications system wherein a plurality of users communicate over a shared channel, the system comprising:

a configurable multi-user detection (MUD) module comprising:

an input for receiving a plurality of discrete values;

a gain factor module that is configurable to select a gain factor corresponding to a desired multi-user detection algorithm; and

a function module that is configurable to select a non-linear function corresponding to the desired multi-user detection algorithm.

78. The system of claim 77, wherein a plurality of configurable MUD modules are arranged to provide multi-stage MUD.

79. The system of claim 78, wherein the plurality of configurable MUD modules includes a first MUD module and a second MUD module, and a first multi-user detection algorithm corresponding to the first MUD module differs from a second multi-user detection algorithm corresponding to the second MUD module.

80. The system of claim 77, wherein the desired multi-user detection algorithm is selected from the group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

81. The system of claim 79, wherein the first and second multi-user detection algorithms are selected from the group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

82. The system of claim 77, wherein the configurable MUD module further comprises a plurality of switches having states that are configurable according to the desired multi-user detection algorithm.

83. A method for providing configurable multi-user detection in a communications system wherein a plurality of users communicate over a shared channel, the method comprising:

configuring a gain factor module to select a gain factor corresponding to a desired multi-user detection algorithm;

configuring a function module to select a non-linear function corresponding to the desired multi-user detection algorithm.

receiving a set of data that provides a plurality of discrete values and canceling multi-user interference according to the desired multi-user detection algorithm.

84. The method of claim 83, wherein a plurality of configurable MUD modules each including the gain factor module and the function module are arranged to provide multi-stage MUD.

85. The method of claim 84, wherein the plurality of configurable MUD modules includes a first MUD module and a second MUD module, and a first multi-user detection algorithm corresponding to the first MUD module differs from a second multi-user detection algorithm corresponding to the second MUD module.

86. The method of claim 83, wherein the desired multi-user detection algorithm is selected

from the group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

87. The method of claim 85, wherein the first and second multi-user detection algorithms are selected from the group consisting of mixed Gaussian (MG), decoupled Kalman (DK), parallel interference cancellation (PIC), and partial parallel interference cancellation (PPIC).

88. The method of claim 83, wherein the configurable MUD module further comprises a plurality of switches having states that are configurable according to the desired multi-user detection algorithm.